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GENERAL ARTICLES

A STUDY OF THE INCIDENCE AND EPIDEMIOLOGY OF TUBERCULOUS INFECTION IN THE ELEMENTARY SCHOOL POPULATION OF THE COUNTY OF RADNOR

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THERE exists an impression that tuberculosis is rife in the rural areas of Wales. Hutchinson[1] drew attention to this fact when he carried out an investigation in a Welsh country parish; Wade[2] and Chalke[3] in thorough and exhaustive enquiries into the high incidence of tuberculosis in certain parts of North Wales further concentrated interest and even alarm in this subject. That the alleged high incidence is more apparent than real, unless some obvious industrial hazard accounts for it, at least as far as the most rural of all the counties of England and Wales is concerned, is suggested by the comparatively low yearly mortality and morbidity rates from tuberculosis in Radnor. The mortality rates per million for the County of Radnor and for Wales and Monmouth are given in Table I for each year of the ten-year period 1931-40.

Cox,[4] however, stressed the fallacy of relying on mortality and morbidity rates as indications of the true incidence of tuberculosis in an area. Evaluation of the exact incidence of tuberculous infection among an elementary school population, inasmuch as it is largely a static population, would give an accurate reflection of the true position with regard to tuberculosis in any given area. It would then be possible to refute or confirm what has by this time become almost an accepted fact—viz., the existence of a high incidence of tuberculosis in Welsh rural areas. The acceptance of this contention was fostered by the findings of the Ministry of Health's Special Report[5] when the parlous state of the general housing and sanitary conditions was given so much prominence. In the same report is stated that " by the age of 15 about 75 per cent. of the population have been infected with tuberculosis." No authority, however, was quoted in support.

The discovery of the actual incidence of tuberculous infection would be

interesting but in itself serve little practical purpose unless the facts elucidated could be utilised in the control of the disease. For this it is necessary to study the epidemiological history of each positive reactor, and thereafter try to decide the most important of the factors concerned. Chi'u, Myers and Stewart[6] found in an eight-year follow-up that 15·02 per cent. of 446 positive reactors developed re-infection tuberculosis, in contrast to 1·68 per cent. of 772 negative reactors who developed clinical disease. The ratio of mortality in the two groups was 38 : 1. The factors affecting the propagation and spread of tuberculosis are already known, but it is omission to evaluate their relative importance that has failed to alleviate the incidence. The figures published by Chi'u and his co-workers strikingly emphasise this.

TABLE I.—TUBERCULOSIS DEATHS, 1931-40
Rate per 1,000,000

Year	*Wales and Monmouthshire*	*County of Radnor*
1931	1,064	1,010
1932	976	715
1933	986	959
1934	913	484
1935	925	584
1936	861	447
1937	881	809
1938	812	512
1939	759	506
1940	796	392

The scattered and sparse nature of this essentially rural county gives a particularly favourable opportunity to study such factors. The words of Pickles[7] are so apposite and relevant to this investigation as to deserve quotation: " It is given to those of us who do our work in country districts to trace the origin and spread of an infectious disease with an accuracy made possible by our intricate knowledge of the lives of those who are our patients. Their friends, their relations, their habits and pastimes, their love affairs, the markets they frequent, the occasional trips to the seaside or the pantomime, and other details of their relatively simple lives, are matters of common knowledge. We stand, therefore, on a strategic pinnacle for the investigation of epidemic disease. The opportunities of infection are few and are traceable in a way that is impossible in the crowded varied life of a town."

The purpose of this investigation was to survey the incidence of tuberculous infection in the elementary school children of Radnor and to study the sources of such infection and the contributory social and other possible factors.

The method employed to detect the presence of tuberculous infection in the course of this investigation was the " patch test," using double strength tuberculin jelly as prepared by Jensen,[8] a modification of the original method described by Monrad. Before starting the main investigation it was essential that the reliability of the method should be determined, and a small preliminary study was therefore done to compare the reliability of the patch material with the Mantoux test.

Part I

EVALUATION OF THE RELIABILITY OF THE PATCH MATERIAL BY COMPARISON WITH A SIMULTANEOUS MANTOUX TEST

Burell[9] stated that Moro in 1908 employed a precutaneous test by rubbing into the skin an ointment containing equal parts of lanolin and Old Tuberculin. In 1937 Vollmer[10] described a patch test using tuberculin impregnated gauze which possessed a reliability equivalent to the Von Pirquet test. Since that time many articles have appeared in medical literature relating to the efficacy of the patch test in detecting reactors to tuberculosis. The recorded results of the various workers are at once perplexing and confusing. Kererzturi[11] reviewed in tabulated form instances in which the tuberculin patch test reaction was compared with adequately performed Mantoux test (Table II). He found that the patch test failed to identify infection demonstrated by the Mantoux test in 25 per cent. of cases in an investigation he carried out in 1940. It is difficult to reconcile the term " false positive " used in the table. If before the investigation commences certain definite standards are laid down for the acceptance or rejection of a positive result, then all results must be either positive or negative in conformity with those standards. Should this not be so, no valid reply can be given to refute the contention that the majority of the " positive " results are also " false." It must be remembered that anomalies and discrepancies arise even in the results given by the Mantoux test.

Table II.—(From Kererzturi)

Author	*Total Number of Cases*	*Control Tuberculin*	*Both Tests Negative*	*Both Tests Positive*	*Control Positive Patch Negative*	*Control Negative Patch Positive*	*Per cent. False Negative Patch*	*Per cent. Positive Patch*
Vollmer 1938	169	PPD	2	165	1	1	1/166 0·5%	1/3 33%
Vollmer 1938	118	OT	106	10	—	2	— —	2/108 2%
Hart ..	536	OT	436	97	3	—	3/100 3%	—
Leonidoff ..	189	PPD	2	185	2	—	2/187 10%	—
Vollmer 1939	251	OT PPD	4	245	1	1	1/246 0·4%	1/5 20%
Perk ..	880	PPD	561	94	225	—	225/319 71%	—
Hughes ..	100	PPD	—	89	11	—	11/100 11%	—
Pearce ..	712	PPD	492	132	21	67	21/153 14%	67/554 12%
Vollmer 1940	667	OT	616	41	4	6	4/48 9%	6/22 1%
Vollmer 1940	540	PPD OT	9	528	2	1	2/530 4%	1/10 10%
Totals ..	4,162	OT PPD	2,228	1,586	270	78	270/1856 15%	78/2306 3%

Many other investigations not mentioned in Table II have been carried out with no unanimity of opinion. But Crimm, Cookson and Broadbent[12] in their study found complete correlation between the patch test and P.P.D. 0·001 mg. injected intradermally in 1,535 individuals out of 1,556 (1,295 negative, 240 positive)—*i.e.*, 98·6 per cent. of the total number tested. The same degree of correlation was obtained by Court[13] in this country. He used 1·10000 Old Tuberculin for the Mantoux test and reported 98 per cent. reliability in 210 cases. The experience of Vollmer and Goldberger,[14] who found a 100 per cent. conformity among a group of 261 children with active tuberculosis, is particularly encouraging, more especially as this was confirmed by Wolf and Hierwitz.

From the spate of writing and the tangled findings certain facts emerge. In the first place, if the patch test is used under optimum conditions the margin of error is indeed small and in cases of actual infection the test is wholly reliable. The paucity of details recorded of the exact method of preparation of the tuberculin patch material used in the tests is marked. Little is revealed of the keeping quality of the materials employed and the conditions under which they were stored after preparation.

A review of the literature therefore stressed the importance of making a preliminary estimation of the efficacy of the patch material to be used for the actual tests. To do this simultaneous percutaneous and intracutaneous tuberculin tests were done on a selected community where a high proportion of reactions was anticipated. In this way " standardisation " was attained and at the same time invaluable practice in the reading of results.

Personnel

The control tests were made on 88 boys whose ages ranged from 5 to 14 years. This group was of the same age incidence as the children on whom the main investigation was to be carried out. All the boys had been admitted to Highland Moors, a convalescent home situated in the spa town of Llandrindod Wells. The home was established by the Welsh National Memorial Association for the reception of undernourished contacts with cases of open tuberculosis, suspicious cases of tuberculosis with no active symptoms or signs, and a certain number—about 5 per cent.—of convalescent cases of surgical tuberculosis.

Test Materials

The 1-1,000 Old Tuberculin jelly was prepared by Professor Tytler at the Research Laboratories of the Welsh National Memorial Association at Cardiff. Testing materials were kept in a refrigerator when not in use.

The necessity of giving exact details of the preparation and strength of the material has been emphasised by Kelly[15] in his review of the methods and results of tuberculin testing. He ascribed variable results to the fact that different preparations of tuberculin varied greatly in potency and specificity, and pointed out that satisfactory epidemiological measurements cannot be made with such varying yard-sticks. It is proposed, therefore, to give a detailed description of its preparation as given to me by Professor Tytler.

Preparation of Tuberculin Jelly

3·9 g. of gum tragacanth should be ground thoroughly with 8 c.c. of 96 per cent. of alcohol; 30 c.c. of water-free glycerin are added. To this mass, under slow and careful stirring, add 300 c.c. Old Tuberculin. 250 mg. purified tuberculin dissolved in 40 c.c. of a buffer solution should be added. The buffer solution should have the following composition as indicated by Jensen[8] and others—viz., 160 c.c. m/15 KH_2PO_4 solution; 640 c.c. m/15 $Na_2HPO_4\,2H_2O$ solu-

tion; 200 c.c. 2·4 per cent. NaCl solution in CO_2 free distilled water plus 1 c.c. 1 per cent. quinosol solution.

The tuberculin should be added rapidly but with gentle stirring, so that the resulting jelly will be homogeneous. Energetic stirring should be avoided, otherwise bubbles will form. This batch will make about fifty tubes of tuberculin jelly with 4 c.c. in each.

Prevention of the drying of the jelly is absolutely essential; the tubes must therefore be made completely air-tight. When not in use the tubes should be stored in a cool place and if possible in a refrigerator.

The term "tuberculin jelly" has been used in preference to "tuberculin ointment" as used by Jensen. "Ointment" implied that a greasy substance has been used as a vehicle, and furthermore, it might be inferred that it should be applied to the skin by inunction, as was originally described by Moro and Hamburger, without attendant results.

Method of Tuberculin Testing

Mantoux Test

The skin of the forearm was cleaned with methylated ether and 0·1 c.c. of 1:1,000 Old Tuberculin was injected intradermally, a small raised white area ensuing. The result of this test was read after forty-eight and seventy-two hours. The reaction was regarded as positive if œdema and redness were present. If there was no œdema, the reaction was considered negative. For purpose of convenience and comparison, reactions were graded from one plus (+) to four (++++). One plus (+) reaction was indicated by a definite œdema, not more than 10 mm. in diameter and without excessive raising of the dermis. Two plus (++) reaction was indicated by a well-defined œdema in an area from 10 to 15 mm. across with more marked raising of the dermis. Three plus (+++) reaction was indicated by an extensive œdema measuring more than 15 mm. but no necrosis of the skin. Four plus (++++) reaction was indicated by an extensive œdema, redness and a spot of necrosis; it might be associated with malaise and elevation of the temperature. These standards were based on those used at the Henry Phipps Institute.

Patch Test

The area of the skin between the middle third of the scapula and the spine was cleaned with methylated ether. Some tuberculin jelly the size of a split pea was squeezed out of the tube and covered with adhesive plaster 2 inches square. A similar piece of adhesive plaster was applied on the opposite side of the spine as a control, and thus obviated any difficulties that might arise in reading the test should a plaster reaction have occurred.

A positive reaction appeared as a sharply demarcated, infiltrated and reddened area with lichenoid-follicular elevation and œdematous base. In certain cases with sensitive skins non-specific irritation due to the adhesive plaster occurred. This, however, in actual practice, did not interfere with the reading of the test, especially if reference was made to the control plaster. In the case of a negative reaction, should there be a plaster reaction, the area covered by the tuberculin jelly appeared paler than the surrounding skin. In the case of a specific positive with a coincident plaster reaction, the area covered by the tuberculin jelly was of a more intense red with superadded follicles and œdema. Again results were graded from one plus (+) to four plus (++++) according to the degree of intensity of the reactions. One plus (+) less than ten lichenoid-follicular elevations with œdematous base. Two plus (++) more than ten lichenoid follicular eruptions assembled in clear-cut area occupied by the tuberculin jelly. Three plus (+++) confluent eruption with marked indication and elevation in the area occupied by the tuberculin jelly. Four plus (++++) spread of the œdema beyond the area of the plaster.

The plasters were removed after forty-eight hours and the tests were read twenty-four hours later.

Results

Number of boys tested, 88.
Number positive to both Mantoux and patch test, 76.
Number negative to both tests, 11.
Number negative to patch but positive to Mantoux test, nil.
Number positive to patch test but negative to Mantoux test, 1.

NUMBERS IN AGE GROUPS

Age	*Number Positive*	*Number Negative*	*Total*
5 to 9	44	9	53
10 to 14	33	2	35
Totals	77	11	88

CONCLUSIONS

These preliminary investigations showed that the patch test described, using known strength tuberculin incoporated in tragacanth jelly, compared favourably with the Mantoux test in eliciting the presence of tuberculous infection. The patch test revealed the presence of tuberculous infection when the Mantoux test failed to do so in one case. It was found that a sister of this boy who failed to react to the Mantoux test had been living in the same house, and had been admitted to the North Wales Sanatorium suffering from pulmonary tuberculosis.

In 12·9 per cent. of the cases the patch test gave a more definite reaction than the Mantoux test judged by the number of the pluses resulting. In three instances the Mantoux test gave a more definite reaction than the patch test. In 42 instances the degree of the reaction to the tuberculin was the same in both tests. In two instances only were four plus reactions obtained, the degree of reaction being the same in the two tests. Both boys had cervical glands removed previously and both had excessive formation of keloid in the wound area.

No general systemic reactions occurred, but one boy had an enlarged gland in the axilla on the same side as the Mantoux test was done.

PART II

INCIDENCE OF TUBERCULOUS INFECTION

INTRODUCTION

This is the first occasion on which a survey has been made of reactors to a tuberculin test in a complete area administered by a Local Education Authority. This area coincided with the Administrative County boundary of Radnor. Opie[16] and others working at the Phipps Institute, University of Pennsylvania, conducted a survey to determine the prevalence of tuberculous infection among the children of certain schools in Philadelphia. Using the Mantoux test they discovered that approximately 51 per cent. of children 5 years of age were positive, 72 per cent. of children 10 years old, and slightly more than 94 per cent. of children 15 years old. These workers came to the conclusion that the tuberculin test provided a measure of the incidence of tuberculous infection, including both latent and manifest disease in school children of Philadelphia, and permitted comparison with the dissemination of infection elsewhere. All other surveys have been made on selected groups of the community.

It is indeed surprising that tuberculin testing has not been used on a general scale, especially on children up to the age of 15 years. It is even more surprising

that in the Summary of Recommendations of the Report on Tuberculosis in War-time[17] the Committee in its enthusiasm for Mass Radiography did not mention the value of tuberculin testing in the control of the disease. It might be argued that reference was being made to people in industry and the Services, but control and eradication will never be achieved by concentrating attention on one section of the community. Whatever the absolute and ultimate value of Mass Radiography in adults, Myers[18] as a result of vast experience in Lymanhurst Health Centre expressed clearly his opinions of the value of X-ray films of children. He based his conclusions on the studies of 16,824 children examined over a period of years, and stated that these studies indicated that the taking of X-ray films of the chest of children was almost a total waste of time as far as tuberculosis was concerned. He added, however, that when adolescence is reached and on into the years every tuberculin reactor should have an X-ray of the chest at least annually.

A great deal of interest has been centred of late years on the relation of social conditions to tuberculosis. From the enquiries of D'Arcy Hart and Payling Wright,[19] Bradbury[20] and the Committee of Inquiry into the Anti-tuberculosis Services in Wales and Monmouthshire,[5] the impression has been conveyed that the incidence of tuberculosis is high in certain areas on account of the poor conditions generally existing in those areas. It is an irrefutable fact that poverty and tuberculosis are close and ugly allies, but it is never sufficiently stressed that the *sine qua non* for infectivity in tuberculosis of the human type is the existence of open foci in the lungs. That and that alone is the primary and fundamental factor concerned in the spread of tuberculosis. Such factors as poverty, poor housing, malnutrition, racial susceptibility and climatic conditions are important, but they are secondary factors. Hutchinson[1] and Distaso and Carveth Johnson[21] have done invaluable work in stressing the overwhelming importance of infection, as opposed to housing and environmental factor, in the spread of tuberculosis. The high incidence of tuberculosis in poverty-stricken areas is the natural complement and not the direct result of these combined factors, for the simple reason that under poor living conditions the infectious case of tuberculosis has the opportunity of infecting a large number of people by close contact. It is obvious that a susceptible person in close contact with a case of open tuberculosis, even if living under the combined conditions engendered by the affluence of a Crœsus and the architectural genius of a Solomon, will contract tuberculosis sooner or later.

It was felt that this county of Radnor with its sparse and scattered population in comparatively isolated communities offered a golden opportunity of correlating the incidence of tuberculous infection with the general environmental and social conditions of the inhabitants.

Statistics and Social Conditions of area

It is proposed now to deal with the environmental setting of the children concerned in this research.

The Administrative County of Radnor comprises three Urban and five Rural Districts; it covers an area of 301,165 acres (Urban 8,167 acres, Rural 292,998 acres). The Registrar-General gave the following estimates of the population for the year 1940: Urban District 6,460; Rural District 13,960;

County 20,420. Llandrindod Wells (3,621), Knighton (1,759), and Presteigne (1,080) have been given the designation of Urban areas; it will be seen from the actual figures of the population that they are no bigger than large villages. It is the least populous of the Welsh counties, and the sparseness of the population is emphasised by the fact that it has one person per 14 acres. It lies on the English border between Montgomeryshire in the north and Breconshire in the south.

The rateable value of the County on April 1, 1939, was £194,184; product of a penny rate (estimated 1939-40) £811. One parish, Cwmdauddwr, in the Rural District of Rhayader, provided almost exactly half this amount. This sum may seem large compared with the product of the penny rate, amounting to £663, in Montgomeryshire, which is a larger and more populous county. The product of a penny rate in Radnorshire is greatly augmented by the chain of reservoirs within the county belonging to the Birmingham Corporation, situated in Cwmdauddwr Parish. This figure is therefore not a true reflection of the prosperity of the county. The drift of the population from the countryside to the industrial centres has been steady and relentless and the empty shells of derelict houses tell their own sad stories. During the twenty years from 1911 to 1931 the population had declined by 16 per cent. One of the factors adversely influencing this downward trend of the population is undoubtedly the poor housing conditions and absence of sanitary amenities existing in some parts.

The lack of prosperity is no new feature. It is interesting to record that even Cromwell's Commissioners when asked to institute an enquiry for the purpose of assessing the fines on Royalist estates in Radnorshire reported on the general poverty obtaining at the time of their survey. This beautiful county is rich in historical antiquity and legendary mythology, but is poor in material resources, and its inhabitants rely for an existence almost entirely on agriculture. Radnorshire has no rivers of commercial utility and no seacoast, consequently there are no large industries and it is likely to remain essentially a pastoral stock-raising county. There are three stone quarries in the county, but not one employs more than 150 men.

The 1931 Census showed that the largest group of male workers was engaged in agricultural work; of females the largest group consists of persons engaged in personal service, the majority domestic servants.

Until the war agricultural labourer's wages were thirty-two shillings a week. On this amount a man supported his wife and children, the latter often four to five in number. This is small when it is considered that fixed amounts must be spent on rent and clothing. The only way it was possible to economise was by spending less money on food. There are a large number of owner-occupiers in the county, and it is generally recognised that a great deal of apparent poverty exists among relatively wealthy farmers, due to the poor tradition in their mode of living.

General Physical Features

As much as two-thirds of the county is classified as mountain-land. The surface of the county divides itself naturally into (*a*) mountain area; (*b*) high moorland; and (*c*) valleys. The collective name for all the mountain tract is Radnor Forest, occupying the centre of the county; connecting the height of the forest are a number of lesser elevations which sometimes spread out in extensive

boggy tableland. It will be realised, therefore, that the valleys, though fertile and productive, are too small in extent to support a large flourishing community. The average height of the county is well over 1,000 feet above sea-level. This highland tract has not inaptly been compared with an umbrella sheltering the country further eastward from the rain, while itself receiving more than its share of rainfall.

Geology

Brownlee[22] considered there may be a relationship between a high incidence of tuberculosis and geological formations. He pointed out that more phthisis occurred in regions underlain by the Precambrian and Cambrian Formations than in those underlain by the Silurian and Devonian, but concluded that geological conditions influence very largely social conditions.

The soil in Radnor is to a large extent argillaceous and therefore impervious, but there is an improvement in the quality in a small area in the

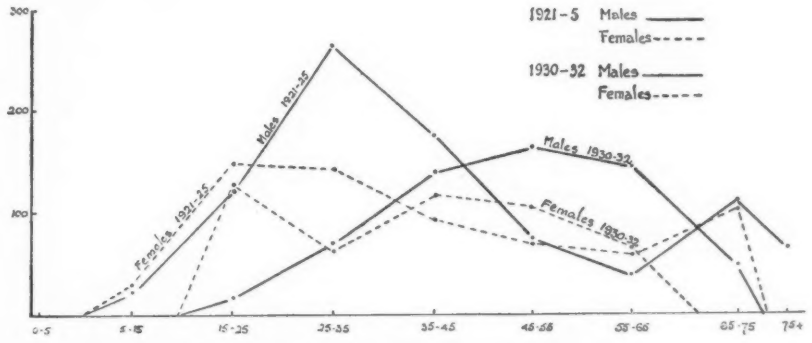

Fig. 1.—Respiratory Tuberculosis. Radnor

Graph illustrating death-rates per 100,000 males and females separately for the two periods 1921-25 and 1930-32

south-eastern part of the county. The greater part of the county belongs to the Silurian System. The Old Red Sandstone or Devonian Rocks cross from Herefordshire to Central Brecon and cut a section of South Radnorshire on the way. Small portions of the same rock appear at the south-eastern end of the county. Bursting through the strata of Silurian and Old Red Sandstone at different parts of the county are the trap rocks. These igneous rocks are of the greatest importance to the general economy of the county as they are the source of the medicinal springs—sulphur and saline—of the spa town of Llandrindod Wells. The presence of Llandrindod Wells in the county largely accounts for the fact that the largest group of females is engaged in personal service.

Industrial Hazards

The absence of any industrial hazard in the county which might adversely affect the incidence of tuberculosis and therefore complicate the issue is reflected by the nature of the curves in Fig. 1. If some industrial hazard had been present there would have been a definite peak recurring in the same age

groups in the two periods under review. True the two peaks approximate in appearance in the 15-25 age group for females, but this is common to England and Wales as a whole. The sharp peak in the 25-35 age group for males in the 1921-25 period is interesting.

The probable reason for this phenomenon was the return to the county of men from the Services after the 1914-18 war. These men, it should be remembered, coming from the midst of an "unsalted" population, were suddenly placed in circumstances on active service where the opportunities for infection were many.

It is reasonable to assume that in the section of the community under review the investigation was not complicated by the presence of any marked unfavourable occupational factor in the community as a whole.

Climate

Gordon[23] found that tuberculosis was more common in districts exposed to rain-bearing winds, and Rogers[24] stated that 60 per cent. of the tuberculosis deaths in India occurred during the hot season and they were increased by rain-bearing winds rather than by actual rainfall. He makes no observations on the influences of either factor on the incidence of infection, which is greatly of more value in studying the epidemiology of the disease than the death rate. The death rate would naturally be more sensitive to sudden fluctuations of climatic conditions than the incidence rate.

Jones,[25] in an investigation he carried out in Anglesey, was unable to come to a definite conclusion regarding the relationship between high rainfall and exposure to rain-bearing winds with the incidence of tuberculosis.

The trees, large and small, all grow somewhat bent to the east and north-east and thus truly indicate the direction of its prevalent winds. It is these continuous west and south-west winds, laden with moisture from the Atlantic, that are responsible for the high rainfall.

The following information has been extracted from a statement received from the Air Ministry Meteorological Office. The figures quoted refer to a 35-year period up to 1940. The only station with a consistent record is Rhayader, which is situated in the western end of the county.

Average Yearly Meteorological Condition at Rhayader

Temperature °F.			*Rainfall*	*Sunshine*		
Max.	*Min.*	*Mean.*	*Inches*	*Total Hours*	*Daily Mean Hours*	*Per cent. of Possible*
53·4	40	46·7	50·6	1350	3·69	30

Average Annual Rainfall—Radnorshire

A map depicting the average annual rainfall of the county shows a close connection between rainfall totals and relief. The "umbrella" effect previously referred to is well illustrated, the rainfall on the west side of the mountain ridge being as high as 80 inches in one area and on the east side as low as 35 inches.

The county has long periods of low temperature with a low annual mean temperature, heavy rainfall and low annual mean temperature.

Habits and Customs

The majority of the inhabitants of the Rural areas are independent hard-working folk. They are not possessed of the herd instinct so characteristic of the Cymru. They do not tend to congregate in places of worship to the extent usually associated with Wales. Overcrowding in ill-ventilated halls and chapels would not be so serious a factor as in parts of North Wales, as suggested by Chalke.[3] This characteristic of independence so admirable, insomuch that it tends to minimise the dissemination of infection, is correspondingly disconcerting to the investigator, when he seeks to ascertain epidemiological facts once infection has been established.

Anthropological Types

The large majority of the people residing in the county are the short, dark, long-headed type. This is the type that normally predominates in the upland regions of Wales. Brownlee[22] and Emrys Bowen[26] have discussed the question of racial predisposition to tuberculosis in so far as it concerned the people of Wales. Bowen concluded that the short, dark, long-headed types, who tended to live poorly in their moorland homes, were very susceptible to the progressive type of the disease. A glance at the curve for the period 1921-25 in Fig. 1 would seem to substantiate this. The nature of the curve for the 1930-32 period, however, does not add confirmation. It has been suggested previously that the peak produced in the curve for 1921-25 in the 15-25 age group was due to the opportunities of massive infection of the men on active service, with the result that the men succumbed to the progressive type of the disease. Later, however, when the majority of the men of this age group remained in the county, no such peak appeared in the curve on the graph on account of the fact that the opportunities for contracting infection were infinitely less. The remote position of inhabited areas in relation to each other is one of the most striking features of the topography of the county. This, coupled with comparatively poor means of communication, places infectious cases in a state of isolation amounting almost to segregation, with the result that fewer people are infected in any age group.

Housing and Sanitary Conditions

Lloyd and Macpherson[27] stressed the significance of contact with pulmonary tuberculosis in the ætiology of pulmonary tuberculosis in young adults, and Hutchinson[1] pointed out the fallacy of concluding that housing *per se* is responsible for a high incidence of tuberculosis. Two factors, one the complement of the other, certainly influence but do not cause a high incidence of tuberculosis in an area where the housing is bad. These factors are: (1) where an open case occurs there are ample opportunities of infecting with massive doses other members of the family whose general health has already been undermined by overcrowding, damp conditions and undernourishment; and (2) where a person has been infected previously, especially if he has been the bread-winner,

he has to live in a poorer district on account of lower rents, thus increasing the number of potential infecting foci in an already impoverished overcrowded area.

The sanitary conditions in the two Urban areas, Llandrindod Wells and Knighton, are satisfactory, but this is not so in Presteigne, where conditions in one part of the town are deplorable. The standard generally may be gauged from the wholly inadequate methods employed for sewage disposal. Most of the sewage is discharged directly into the small river Lugg after passing through a crude settling tank.

In the Rural areas the standards of housing and sanitation are indeed poor. Conditions generally have changed very little in the last sixty years, certainly not for the better. It cannot be alleged that the general improvement in the hygiene and sanitation of the Rural areas has advanced in favourable comparison with the downward trend in the incidence of tuberculosis generally during the same period. Indeed the reverse may be said to be true. In the Knighton Rural Area, the largest of the Administrative Rural Areas, a careful survey revealed the following fact:

Number of houses inspected, 1,099.
Number unfit for human habitation and should be demolished, 97.
Number of dwelling houses in which defects require remedying to bring up to the minimum of the Housing Acts, 898.
Number of houses overcrowded, 12.

These figures eloquently reveal the poor conditions that prevail. It must be borne in mind that the standards adopted in this survey were not by any means strict. In a survey of the housing and sanitary conditions made in 1939 by a Ministry of Health Housing Inspector, the figures of the number of totally unfit houses were far greater. Out of the total of 1,099 houses, 54 had water closets leading into cesspools. Twelve houses had no closet accommodation at all. The remainder had pail privies and midden privies, the contents of which were emptied on the adjoining land and gardens. It is not uncommon to see lavatories constructed above a stream so that the water may carry away the excreta to a point lower down the valley. The streams also become receptacles for tins and other rubbish. This pernicious practice is the more dangerous for the fact that the water supply in general is derived from upland surface water.

It is a sad reflection that a pure water supply for a town of over a million inhabitants is obtained from the county, yet in one school in this district the children have to drink water from an open stream running below the school playground. One hundred and three houses have no water supply within two hundred yards. This lack of one of the most elementary of health amenities is greatly to be deplored. Even the worst slums in our large cities are served by adequate supplies of water. Lack of personal cleanliness is inevitably reflected in dirty and unhygienic surroundings. Many of the defects mentioned have been remedied since the completion of the survey.

Nutrition

In spite of much poor management still existing in the homes and in some instances of definite poverty, there can be little doubt that the general standard

of nutrition of school children has improved. Table III shows the remarkable increases that have occurred in this county.

During the year 1942, 19·8 per cent. of the children examined were found to be undernourished.

In the Report on Maternal Mortality in Wales[28] it was stated that the standard of living was low and that comparatively little farm produce found its way to the home table. It was alleged that eggs, milk and butter were produced for sale outside the area, and the stable articles of diet were bacon, bread and butter and tea. Among large sections of the population there was insufficient intake of natural protective foods and of first-class proteins, and it would appear that the dietary was deficient in calcium, iron, phosphorus and iodine. This is undoubtedly true to some extent, but the figures in Table III fail to substantiate it entirely. As far as school children are concerned the almost universal provision of milk and mid-day meals in the schools in the county, as now established, will obviate in the future any dietary defect in the home.

It is rare to see a case of rickets, which is another indication of the general improvement that has taken place. It is difficult to give a satisfactory reason for this increase in the average heights and weights, as it is only recently that milk and mid-day meals have been universally provided in the schools. The reasons for the increase are probably many: (1) increase in wages; (2) general improvement in health from school medical supervision; (3) families tend to be much smaller with the consequence that more food is available for each member of a family; (4) the opening up of communications, with the result that there has been less inbreeding; (5) the general evolutionary tendency for the race to get bigger; (6) cookery instruction at school and the Women's Institutes. Certainly there is room for improvement, and head teachers have remarked how very much better the children have been in general health, alertness and attendance since mid-day meals have been served in the schools. This is not surprising, as on several occasions inspection showed that the food the children brought for their mid-day meals consisted of sandwiches made of bread and jam or bread and butter and jam, and cake or tart. This was wholly inadequate, more especially as some of the children walk many miles to school. Most of the children stated that they partook of a hot meal when they went home at night. Even so, it must be rare for them to have fresh meat, as communications with the shopping centres are extremely poor. It is certain that in most cases the amount of vitamin A in the diets, especially in winter, was inadequate.

It is impossible to over-emphasise the importance of correct and adequate feeding of school children. The weight charts of the children at Highland Moors Convalescent Home revealed remarkable results. Fifty charts were taken at random and it was found that by the end of three months the children, whose ages ranged from 5 to 14 years, had gained on the average 7 lb. It is amazing how much their general health had improved by a combination of judicious feeding and adequate rest. It was interesting to note the adverse effect on the weight of any temporary upset in the children's health. A cold or bilious attack would cause loss of weight up to 3 pounds in a week, but in subsequent weeks the normal increase was attained. The value of a weight chart in children as an indication of the state of health has not been sufficiently stressed. A monthly weight chart was taken in all the tuberculin reactors.

Infectious Disease

MacNalty[29] drew attention to the influence of measles and whooping cough in producing conditions favourable to the subsequent onset of pulmonary tuberculosis. The county, on the whole, has been comparatively free from epidemic infectious disease. No school was closed during the year 1942 on this account.

Schools

Distaso and Carveth Johnson[21] thought the elementary schools had not been a centre for the transmission of infection in the investigation they carried out in a village in the neighbouring county of Brecon. The chief danger of transmitting pulmonary tuberculosis in a school was from a teacher suffering from chronic phthisis. On the other hand, poor hygiene and sanitary conditions in the schools might well lower resistance to the disease. At the time of the investigation there were fifty-one elementary schools in Radnorshire and the standard of general hygiene was poor. Although no overcrowding existed and ventilation was adequate the heating in all the country schools with one exception was by means of slow combustion stoves or open fires, so that on cold days children were forced to crowd round one fire to keep warm. Cloak-room accommodation was often inadequate and the clothes were huddled together. A number of the schools had pail closets and in two—midden privies. The excreta from the pails was emptied on land adjoining the school. Cummins and Ackland[20] demonstrated the presence of living tubercle bacilli in the effluent of a septic tank of a hospital for tuberculous patients. It is unlikely, however, that this can be considered a factor influencing the incidence of tuberculous infection, but it accentuated the undesirability of this procedure.

Bovine Tuberculosis

There is no evidence to suggest that the incidence of tuberculosis among cattle in Radnorshire is high. The facts available indicate that the incidence is very low. In any case, as far as the schools themselves are concerned, instructions are given to the teachers to ensure that the milk is brought to the boil before it is given to the children.

Of late years, the Ministry of Agriculture, through its Regional Veterinary Officers, has been very active in trying to eradicate tuberculosis in cattle. When the Attested Herds Scheme was mooted, a number of farmers had their herds tested for tuberculosis. In Radnorshire it was found that only 2 per cent. of the 3,000 cows tested gave a positive reaction. When a vendor under the milk-in-schools scheme is accepted, the name is sent to the Regional Veterinary Inspector, who examines every cow in the herd for clinical signs of tuberculosis. In spite of all these examinations five cows only had been taken under the Tuberculosis Order in four years. Recently a tuberculin survey was made of all the cattle in a large parish in the southern part of the county, and it was remarkable to find that less than 1 per cent. reacted to the tuberculin test. This compares favourably with statistics from other counties. This satisfactory state of affairs can be attributed to the fact that in the past Radnorshire has been almost entirely a stock-raising and not a milk-exporting county. Milking cows

are not in that case bought from areas outside the county. Added to this the cattle are almost all either of the Hereford breed or cross-bred Hereford-Shorthorn, which are reputed to be more resistant to tuberculosis. Even if they are not really more resistant than other breeds, they have certainly not in the past been over-milked, with consequent lowering of their resistance.

Enough has been said to indicate that it is probable that tuberculosis in cattle is not a formidable factor in increasing the incidence of tuberculous infection in the county.

DETAILS OF INVESTIGATION

The permission of the Local Education Committee was obtained to proceed with the survey. The whole-hearted co-operation of head teachers and of parents throughout the county was one of the most gratifying features. Each head teacher was requested to distribute circular letters to the children for their parents or guardians. The letter explained the scope of the survey and the benefits that would result. Parents were informed that unless the head teacher was notified to the contrary in writing, it would be assumed that they would be pleased to take advantage of the scheme. The idea was welcomed with enthusiasm. The number of refusals was less than 2 per cent. This is the more remarkable and encouraging when it is realised that in the Philadelphia Survey[16] no less than 39·4 per cent. in the elementary schools and 77·5 per cent. in the higher schools refused to submit to the test. The greatest obstacle to the progress and success of that survey was the failure of parents to permit examination of their children. The Mantoux test, involving an injection, which children so much dislike, was used, so that the importance of devising a reliable test which avoided an injection was obvious.

Examination of Children

Forty-eight hours after application the plaster and jelly were removed, and the results read twenty-four hours later—that is, seventy-two hours after the original application.

All cases indicating a positive result were submitted for examination. The homes were then visited to interview the parents and to trace the source of infection and method of spread. At the same time advice was given on the prophylactic care of the child.

Houses were inspected and classified as either good, fair, or bad. The criteria which indicated in which category each should be placed were as follows:

(*a*) Good. Houses well ventilated, well lighted, clean, dry and with sufficient accommodation for dwellers.

(*b*) Fair. Houses well ventilated, clean, well lighted, not persistently damp, with sufficient accommodation for the dwellers, but did not in all respects come up to the strictest standards of the requirements of the Housing Acts—*e.g.*, drainage.

(*c*) Bad. Houses poorly ventilated, badly lighted, dirty, persistently damp and overcrowded.

TABLE III.—AVERAGE HEIGHTS AND WEIGHTS OF RADNORSHIRE SCHOOL CHILDREN

	1911						1939					
	Boys			*Girls*			*Boys*			*Girls*		
Yrs. of Age	*No. Examined*	*Ht. in in.*	*Wt. in lb.*	*No. Examined*	*Ht. in in.*	*Wt. in lb.*	*No. Examined*	*Ht. in in.*	*Wt. in lb.*	*No. Examined*	*Ht. in in.*	*Wt. in lb.*
5	54	40·6	37·8	55	39·8	35·3	86	42·8	42·8	70	42·7	38·2
6	92	42·5	42·5	69	42·5	40·3	23	44·4	45·7	41	44·2	46·9
7	65	43·9	44·0	50	43·9	42·8	15	46·6	51·0	15	45·3	45·2
8	28	46·1	51·8	47	46·1	46·8	119	49·7	58·0	103	48·9	54·9
12	16	55·3	71·5	28	54·8	72·8	91	56·7	80·9	80	57·1	84·8
13	210	55·8	75·0	225	56·8	75·0	29	57·7	85·0	23	58·3	88·8

TABLE IV.—TUBERCULIN REACTORS IN URBAN SCHOOLS

Schools	*Number on Books*	*Number Tested*	*Number Positive*		*Total Positive*	*Total percentage Positive*
			Boys	*Girls*		
LLANDRINDOD WELLS URBAN						
Llandrindod Wells Council	183	163	7	8	15	9·2
Llandrindod Wells C. of E.	99	95	9	1	10	10·4
Llandrindod Wells County (11 to 14 years of age)	54	51	3	5	8	17·6
Llandrindod Wells Total ..	336	309	19	14	33	10·7
KNIGHTON URBAN						
Knighton C. of E.	210	201	18	8	26	12·9
Knighton residents at Presteigne County School ..	42	39	2	7	9	23·0
Knighton Total	252	240	20	15	35	14·5
PRESTEIGNE URBAN						
Presteigne, Hereford St. ..	53	40	0	2	2	5·0
Presteigne C. of E. (including County School children under 15)	98	98	2	1	3	3·1
Presteigne Total	151	138	2	3	5	3·6
*RHAYADER (URBAN)						
Cwmdauddwr Junior ..	70	70	6	2	8	11·4
Rhayader Senior (including County School children under 15)	78	76	4	5	9	11·8
Rhayader Total	148	146	10	7	17	11·6
URBAN TOTAL	897	833	51	39	90	10·8

* Rhayader has no Urban Council, but is classified as Urban on account of its size compared with Presteigne, which has an Urban Council.

TABLE V.—RURAL SCHOOLS

Schools	Number on Books	Number Tested	Number Positive		Total Positive	Total percentage Positive
			Boys	Girls		
KNIGHTON RURAL DISTRICT						
Beguildy	19	19	0	0	0	0
Bleddfa	17	14	0	1	1	7·1
Heyope	28	25	1	0	1	4·0
Glanithon	19	12	0	0	0	0
Llaithddu	34	28	0	2	2	7·1
Llanbister Cantal	19	15	0	0	0	0
Llanfihangel Rhydithon	27	21	0	0	0	0
Llangunllo	43	35	2	1	3	8·6
Norton	27	20	0	0	0	0
Stanage	26	26	0	0	0	0
Whitton	30	21	0	0	0	0
Llanbister Council	42	41	0	0	0	0
Cascob	10	7	0	0	0	0
Llandewy	48	40	1	0	1	2·5
Crugybyddar	16	16	0	0	0	0
Knighton Rural Total	405	340	4	4	8	2·4
NEW RADNOR DISTRICT						
Old Radnor	60	53	0	2	2	3·7
Evancoyd	48	38	2	2	4	10·5
Gladestry	28	28	0	0	0	0
Glascwm	12	10	0	1	1	10
Franksbridge	35	32	1	1	2	6·2
Newchurch	17	12	0	0	0	0
New Radnor	78	72	1	1	2	2·8
Llandegley	28	23	1	0	1	4·3
New Radnor Total	306	268	5	7	12	4·4
PAINSCASTLE DISTRICT						
Boughrood	38	34	0	0	0	0
Clyro	27	26	1	0	1	3·8
Ffynnongynydd	27	26	0	0	0	0
Painscastle	37	32	0	0	0	0
Llandilo Graban	35	27	0	1	1	3·7
Llowes	18	18	0	0	0	0
Painscastle Total	182	163	1	1	2	1·2
COLWYN RURAL DISTRICT						
Howey	34	29	2	3	5	17·2
Pencerrig	48	33	1	0	1	3·3
Llanelwedd	28	26	2	1	3	11·5
Llansaintffraed	20	18	1	0	1	5·5
Lower Llanedw	28	28	1	0	1	3·5
Aberedw	25	21	0	0	0	0
Colwyn Total	183	155	7	4	11	7·1

TABLE V.—RURAL SCHOOLS (continued)

Schools	Number on Books	Number Tested	Number Positive		Total Positive	Total percentage Positive
			Boys	Girls		
RHAYADER DISTRICT						
Abbeycwmhir	21	18	1	0	1	5·5
Bwlchysarnau	19	14	0	0	0	0
Llanbadarn Fawr	58	52	0	1	1	1·8
Llanyre C. of E.	86	62	0	2	2	3·2
Nantmel C. of E.	19	18	2	0	2	11·1
Nantmel Gaufron	23	23	0	0	0	0
Nantmel St. Mark's ..	13	11	1	1	2	18·2
St. Harmon's	27	27	1	2	3	11·1
Nantgwyn	20	18	1	0	1	5·5
Rhayader Rural Total ..	286	243	6	6	12	4·9

TABLE VI.—COMBINED URBAN AND RURAL SCHOOLS

District	Number on Books	Number Tested	Number Positive		Total Positive	Total percentage Positive
			Boys	Girls		
Llandrindod Wells Urban ..	336	309	19	14	33	10·7
Knighton Urban	262	240	20	15	35	14·5
Presteigne Urban	151	138	2	3	5	3·6
Rhayader (Urban)	148	146	10	7	17	11·6
Urban Total	897	833	51	39	90	10·8
County Schools (Rural) ..	178	174	4	2	6	3·4
Knighton Rural	405	340	4	4	8	2·4
Colwyn Rural	183	155	7	4	11	7·1
Rhayader Rural	286	243	6	6	12	4·9
New Radnor Rural	306	268	5	7	12	4·4
Painscastle Rural	182	163	1	1	2	1·2
Rural Total	1,540	1,343	27	24	51	3·8
County Total	2,437	2,176	78	63	141	6·5

TABLE VII.—TUBERCULIN REACTION IN BOYS AND GIRLS IN THE DIFFERENT AGE GROUPS

Age	No. of boys in each age group	No. of boys positive	Percentage of boys positive	No. of girls in each age group	No. of girls positive	Percentage of girls positive	Total positive in each age group	Total tested in each age group	Total percentage positive
5	121	4	3·3	106	4	3·8	8	227	3·5
6	124	6	4·8	114	1	0·9	7	238	2·9
7	113	6	5·3	126	6	4·8	12	239	5·0
8	129	6	4·7	110	7	6·4	13	239	5·4
9	124	10	8·1	121	10	8·3	20	245	8·2
10	128	12	9·4	113	7	6·2	19	241	7·9
11	116	10	8·6	123	7	5·7	17	239	7·1
12	99	8	9·1	110	6	5·5	14	209	6·7
13	109	10	9·2	114	9	7·8	19	223	8·5
14	32	5	15·6	44	7	15·9	12	76	15·8
Total	1,095	77	7·1	1,081	64	5·8	141	2,176	6·5

TABLE VIII.—TUBERCULIN REACTION IN BOYS AND GIRLS IN THREE-YEAR AGE PERIODS

Age period	*No. of boys in each age period*	*No. of boys positive*	*Percentage of boys positive*	*No. of girls in each age period*	*No. of girls positive*	*Percentage of girls positive*	*Total positive in each age period*	*Total tested in each age period*	*Total percentage positive*
5-7	358	16	4·5	346	11	3·2	27	704	3·8
8-10	381	28	7·3	344	24	7·0	52	725	7·2
11-13	324	28	8·6	347	22	6·4	50	671	7·5

RESULTS

The results of the survey are given in Tables IV to IX. The main facts which emerged are as follows:

(1) The proportion of reactors to the tuberculin test—using Monrad double strength tuberculin jelly—was low among the children of elementary school age in Radnorshire—6·5 per cent. for the whole county (Table VI).

(2) The incidence was higher in the small urban areas (Llandrindod Wells 10·7 per cent., Knighton 14·6 per cent., Rhayader 11·6 per cent., with the exception of Presteigne 3·6 per cent.) than in the rural areas (Knighton 2·4 per cent., Colwyn 7·1 per cent., Rhayader 4·9 per cent., Painscastle 1·2 per cent., and New Radnor 4·4 per cent.). The total percentage of positive reactors in the urban areas was 10·8 per cent. as compared with 3·8 per cent for all the children tested in the rural areas (Tables IV, V and VI).

(3) In the urban area of Presteigne the incidence was 3·6 per cent. as compared with 10·7 per cent. in Llandrindod Wells (Table IV).

(4) 88·4 per cent. of the school children were submitted to the test. Apart from 2 per cent. who refused examination, the remainder were absent from school.

(5) Out of a total of 141 positive reactors, 29·8 per cent. lived in "Good" houses, 50·4 per cent. lived in "Fair" houses, and 19·8 per cent. lived in "Bad" houses.

(6) 31·2 per cent. were classified as "excellent," 53·2 per cent. as "normal," 14·9 per cent. as "sub-normal," and 0·7 per cent. as "bad" with regard to nutrition.

(7) 76·6 per cent. were definitely known to have been in contact with a case treated for pulmonary tuberculosis.

(8) The incidence of tuberculous infection in Rhayader area was 7·4 per cent. where the rainfall is high (50-80 inches per annum), whilst the incidence in the Knighton area was 7·2 per cent. where the rainfall is lower (35-40 inches per annum).

(9) The incidence of tuberculous infection tended to increase with each three-year age group (Table VIII).

(10) 7·1 per cent. of the boys were infected compared with 5·8 per cent. of the girls (Table VII).

EPIDEMIOLOGICAL NOTES

It might have been expected that difficulties would be met when trying to trace the source of infection, and in fact this proved in many instances to be the case. Apart from natural reticence many parents have an inherent dread of tuberculosis. However, persistence and consultation with local general practitioners, district nurses and head teachers in most instances gave the necessary information. From the preventive aspect, cases where the infective sources could not be traced presented greater anxiety, and it was in these cases that efforts were redoubled in an endeavour to persuade the rest of the adult family to come to the tuberculosis dispensary for examination. It is the unsuspected adult case which acts as the unconscious reservoir of infection that will inevitably bring about manifest disease in the susceptible child. When the source is known, practical steps can be taken to minimise infection. As Lissant Cox in 1933 stressed: " Find, isolate, educate and treat the adult positive case, and thus safeguard the child."

Many examples of the varying modes of infection and of the chance sources of contact with open phthisis were met in the course of the investigations. A selection by way of illustration is included here for the light they throw upon the paths of infection. (See Table IX in Appendix.)

Case No. 1. (Table IX in Appendix).—Girl aged 10 years was often in contact with her grandfather, who had a persistent cough for seven years. The grandfather, on investigation, was found to have a cavity in the lung and a tuberculous larynx.

Case No. 8.—Girl aged 9 years. On enquiry it was found that the only possible known contact was a soldier's wife, a notified case of phthisis, who had been billeted on the mother. The little girl spent almost every evening in the front room making doll's clothing. The brother, aged 11, who did not come in direct contact with the billetee, was negative to the test. The child showed a (+++) reaction.

Cases Nos. 14 and 29.Two boys, brothers, aged 10 and 11 years, reacted strongly (+++). There was no history of contact with a case of tuberculosis, but it was discovered that the father had died three years previously, according to the death certificate, from (1) broncho-pneumonia, and (2) acute pneumothorax. Inquiry into the previous history revealed that the man had suffered from pleurisy and chronic cough. There is little doubt that the father was the source of the infection, and incidentally indicates how complete reliance cannot be placed on mortality rates of tuberculosis.

Case No. 19.—Boy aged 9 years reacted strongly (+++). It was discovered that he spent his summer holidays in Wolverhampton with two uncles, both of whom were notified cases of tuberculosis. Twin brothers, aged 7 years, were both negative, and neither had been away from the county, nor had been in contact with the uncles.

Case No. 22.—Boy aged 10 years. Two other members of the family were negative. This boy was very friendly with case number 10, a boy of his own age and was continually in and out of the house where his friend lived, and where the mother was bed-ridden from phthisis after many years' suffering. It is not unlikely, therefore, that this was the source of the infection, especially as the boy had never been away from home, and the two brothers, who were negative, were not in the habit of visiting the house mentioned.

Cases Nos. 28, 36, 98, 109, 121 and 125 can be taken together, as they were all in close contact outside their own houses with cases of phthisis, five of whom were confined to bed. In three out of the six cases the reactors were the only child members of the family to demonstrate a positive reaction, whilst their brothers and sisters were negative, but had been in contact with the phthisical patient cited. The other reactor had no brothers or sisters. The children were taken to the infected houses in four instances, so that the mother could help her neighbour to do the housework. There was no family relationship between the reactors and the cases with which they came in contact.

Case No. 72 is somewhat analogous to the ones quoted above and demonstrates how a child may quite unsuspectedly be exposed to a dangerous degree to tuberculous infection. During the summer holiday a girl aged 11 years stayed in the Midlands with her aunt. Lodging with the aunt was a girl who had been working in a factory, but was after some months of ill-health forced to give up work, and then found to have pulmonary tuberculosis.

Cases Nos. 26, 27, 81 and 82 make an interesting group from an epidemiological point of view. Cases 26 and 27 were two girls aged 12 and 13 respectively. An elder sister aged 22 years died four years previously from phthisis and tuberculosis of the kidney which she contracted from her sweetheart; she died in the same house as the two girls who gave a positive reaction.

Cases Nos. 81 and 82, two boys aged 9 and 10 years respectively, are also interesting from an epidemiological point of view. An aunt was engaged to a chauffeur who was notified as suffering from tuberculosis, and later died. Six months after his death the aunt was taken ill with phthisis and sent to a sanatorium. She returned home and was nursed by another sister, a strong healthy woman of 38 years of age. The aunt died, and the sister later contracted phthisis and has recently returned from a sanatorium still far from well. One of the boys lived with his aunt, and the other frequently visited the house. Chalke[3] in his report drew attention to the possibility of spreading infection by sweethearts. In neither family could any history of tuberculosis be traced previously. In the light of these specific instances, the policy of releasing cases of tuberculosis from the sanatoria at the commencement of the war makes sad reading.

Cases Nos. 9, 40 and 50 had been in contact with servants who had suffered, and since died, from pulmonary tuberculosis. In all three cases the parents were certain that to their knowledge the children had not been in contact with cases of tuberculosis and in no instance was there a family history. In the case of No. 40, a maid who had been in a sanatorium and later died of tuberculosis was engaged during the period of the mother's confinement to look after the girl when she was 8 years old. Two younger brothers of this girl were negative to the test.

Cases Nos. 98 and 136, two brothers, both of whom gave a positive reaction whilst their younger brother was negative. It was discovered on investigation that the two elder brothers had been staying in another county with an aunt whose husband—not a blood relation of the boys concerned—suffered from tuberculosis. The younger brother who failed to react had not been away from home and had not been in contact with the source mentioned.

Case No. 129 is also of particular interest. Four children in the same family were tested, and a boy aged 9 years was the only one that reacted. The one place he had been away where the others had not was in hospital next to a boy aged 16 years suffering from diabetes. After six weeks in hospital the boy suffering from diabetes was X-rayed and discovered to have pulmonary tuberculosis. He was removed to a sanatorium and soon afterwards died. When the positive reactor was out of bed he was continually playing with his neighbour's books and sharing his sweets and chocolate.

Two cases in which no contact could be traced—viz.:

Cases Nos. 89 and 126 lived in public houses. In country public houses the bar, kitchen and dining-room are all one and the same, and the inhabitants of the house and the clients frequently crowd round the fireplace, spitting is frequent and uncontrolled. Infection in this way is easily spread.

Case No. 119 was discovered to be a sister of the teacher in charge of the infants' class in the same school. It transpired that the teacher had been treated at a sanatorium following pleurisy. On account of this it was feared that she might have infected the children in the class, but one other child only reacted, whilst the teacher's brother, aged 10 years, was negative. Sputum and X-ray tests proved negative, and it was learnt that the source of infection both in the case of the teacher and her sister was a lodger who had two years previously been living in the same house. He died from pulmonary tuberculosis within a month of leaving the home. Fairfax Hall[21] has already indicated the importance of the periodic medical examination of school teachers, domestic servants and nurses, so that open cases of tuberculosis will be discovered and the possibility of the infection of children thus minimised.

Cases Nos. 43, 44 and 45, a sister and two brothers, aged 10, 7 and 13 years respectively, all reacted strongly (+++) to the patch test. There was no family history of tuberculosis and no history whatsoever of known contact. The cause was discussed with a doctor in the area, who suggested that the source of infection might be the husband of an elder sister of the reactors who had been staying in the house continuously for the last nine months. He had for some time been employed in a factory in the Midlands, but was often away from work owing to a "weak chest." He had a persistent cough. It was suggested that he should come to be investigated by the tuberculosis physician. The reactions were so vivid and occurred to the same extent in all three that I feel that the source of the infection was in the house itself.

Cases Nos. 31 and 99 required special consideration. Both cases revealed a strongly positive reaction which suggested recent contact. It was found that one child, a boy aged 9 years, had been staying in South Wales with his grandfather, who was suffering from silicosis and had to retire prematurely from a coal-mine; whilst in the other case a girl aged 14 years spent a fortnight of her summer holidays with the maid's family also in South Wales; staying at the house was the maid's brother, who had for some years suffered from silicosis. This is particularly interesting in view of the work of Enid Williams,[22] who indicated the frequency with which tuberculosis is associated with silicosis.

Two children whose mothers died, in one case immediately after the confinement and in the other during the third week of the puerperium, proved negative to the patch test. In the case of the second child the mother was removed to a sanatorium the day after the confinement. Neither child came in direct contact with the mother after the confinement. What the Grancher System sought to achieve by design was accomplished in these instances by accident. Whatever may be the moral or social implications of this system, no one can deny the soundness of its conception, based purely on epidemiological principles.

Six cases which were definitely known to have been in close contact with notified cases of tuberculosis failed to react to the test. In two instances that were X-rayed, evidence of calcified hilar glands were seen. The others so far have not presented themselves for X-ray examination. It is reasonable to assume that the infection in these cases had become obsolete. The calcified masses may be regarded as the tombstones of the dead tubercule bacilli within their interstices. At the same time it may be argued that even a tuberculin survey of this kind does not reveal the entire picture, if the term " tuberculous infection " includes invasion of the body tissues at some time or other in the past with tubercle bacilli. However, from a practical point of view the real issue is that of existing infection as opposed to obsolete invasions. It is not nearly so significant to determine how many children have been infected in the past as it is to learn how many harbour virulent tubercle bacilli in the body, and therefore may at any time unless special care is taken develop tuberculous disease.

Discussion

The environmental circumstances which existed in the county at the time of this investigation were in the main the same as those that have time and again been quoted as reasons for a high incidence of tuberculosis in any area. They were poor housing, bad sanitation, inadequate feeding, high rainfall, low sunshine hours, low mean temperature, exposure to rain-bearing winds, impervious soil resulting in persistent damp conditions, susceptible anthropological types, and fatigue, in this instance engendered by walking long distances to school and keeping late hours.

Contrary to expectation, the incidence of tuberculous infection among the elementary school population in Radnorshire, as indicated by the patch test using Monrad double strength tuberculin jelly, was low—6·5 per cent. for the whole county. The incidence of tuberculous infection was higher in the combined Urban areas (10·8 per cent.) than in the Rural areas (3·8 per cent.) In spite of the poor housing and sanitary conditions in Rural areas the incidence was low. In the case of the Urban areas the incidence of tuberculous infection in Llandrindod Wells, where the standards of housing and sanitation were good, was 10·67 per cent., whilst the incidence in Presteigne was only 3·6 per cent., where the housing and sanitation were on the whole extremely poor. The incidence of infection was almost the same in the Rhayader area (7·4 per cent.), which has a high rainfall and is exposed to the west and south-west winds, as in the Knighton area (7·2 per cent.), which has a lower rainfall and is protected by Radnor Forest from these moisture-laden winds. The colour of

the hair of positive reactors was noted and there was no preponderance of any one colour.

The percentage of children showing a positive reaction who lived in " bad " houses was small (19·8 per cent.), whilst the number of children who came from " fair " and " good " houses was surprisingly high. The bad housing conditions in the Knighton Rural area and the Presteigne Urban area have been the subject of special comment, and therefore give these figures special significance.

As many as 31·2 per cent. of the positive reactors were well nourished; 53·2 per cent. were normally nourished; 14·9 per cent. were subnormally nourished and only 0·7 per cent. were badly nourished as judged by the Board of Education standards. These figures should be considered in the light of the fact that in 1942, the same year that this investigation was carried out, 20·6 per cent. were well nourished, 64·7 per cent. were normally nourished, 14·5 per cent. were subnormally nourished, and 0·2 per cent. were badly nourished, of all school children examined.

Among positive reactors, one adverse factor and one only was common to the large majority. That factor was close contact with a case of pulmonary tuberculosis.

In the course of the investigation I was greatly impressed by the fact that the poorly clad, unkempt children, frequently members of large families in poor circumstances, almost without exception failed to reveal a positive reaction. These children had time and again been presented to me as " Special Cases " at school medical inspections either by the head teacher or school nurse, as it was thought they must be tuberculous on account of their physical and environmental conditions. On investigation, no case of " open " tuberculosis could be traced in the families concerned. Added to this, they were too poor in most instances to travel to large populous areas outside the county, and so possibly come in contact with infectious tuberculous cases.

Two points of fundamental importance were revealed, one the direct complement of the other—viz.: (1) the low incidence of tuberculous infection; and (2) the sparseness of the population in the county. Unhesitatingly it may be said that the incidence of tuberculous infection was low in Radnorshire on account of the fact that in the Rural areas more especially people live in small widely separated communities, with the result that an infectious case is isolated in a way almost amounting to segregation.

Two diametrically opposed schools of thought have evolved in the modern concept of tuberculosis. The first contends that recovery from a primary infection confers an immunity which in subsequent years protects the person from ordinary re-infections. The second school contends that the primary infection fails to immunise, and that it furnishes a source of virulent tubercle bacilli and allergy both of which are necessary for the development of re-infection tuberculosis. This, however, cannot be universally correct of the cases in this series, as two failed to react to the test, although they were known to have been at some time in contact with open tuberculosis and X-ray examination demonstrated a healed tuberculous lesion in both of them.

The infection of children by tubercle bacilli has been regarded as beneficial, as it was contended that they would in future be more resistant to tuberculosis. The results of the work done by Chi'u, Myers and Stewart[6] cannot be too

strongly emphasised to the propounders of this hypothesis. These workers indicated quite definitely the risk attendant upon the invasion of the body tissues with tubercle bacilli in childhood, when they discovered the comparatively high proportion of tuberculin-reactors that developed tuberculous disease. To rely on a previous infection to confer an immunity to tuberculosis is a dangerous fallacy, as it is impossible to control the size of the infecting dose. Even if this were possible, the degree of resistance of the individual child cannot be assessed. Immunity in tuberculosis is essentially relative, and an overwhelming dose of tubercle bacilli may at any time overcome resistance. Eradication is contingent upon prevention, and not upon biological empiricism. In view of these observations, the future course and history of the two cases, with healed lesions mentioned above, will be interesting and revealing.

The importance of carrying out tuberculin tests on children is stressed by the fact that only 5 out of the 141 reactors revealed, on careful clinical examination, any physical sign that might necessitate reference to the tuberculosis physician.

The relationship of housing to tuberculosis has received a great deal of attention. It is significant that in spite of all that has been written on this subject, the incidence of tuberculous infection was lowest in Presteigne, the worst of the Urban areas, and in the Rural districts where the housing and sanitary conditions were bad. Special attention has already been drawn to the poor conditions in the Knighton Rural district where definite and reliable data were available. Yet the incidence was as low as 2·4 per cent. In this area there were twelve houses which were overcrowded, but no child from these houses gave a positive reaction. This happy result can be entirely attributed to the fortunate fact that no infectious case of tuberculosis resided in any of these overcrowded houses.

Before a national rehousing scheme is embarked upon with the idea of reducing the incidence of tuberculosis, it would be well to examine the matter in the light of the true facts of the epidemiology of the disease. The relationship between housing conditions and respiratory disease was discussed in a Special Report of the Medical Research Council.[33] The inhabitants of two areas, one in a poor-class quarter and the other in a re-housing scheme, each of which contained a population roughly 1,000 persons, were observed by means of weekly house-to-house visists from September 1928 to September 1929. The results showed that there was greater morbidity from respiratory diseases in the re-housing area than in the slum quarters. The Report concluded that one of the chief results of the enquiry was possibly to indicate the difficulties of field surveys undertaken to determine in a poor-class population the incidence of respiratory disease and its relation to environmental conditions.

Evans[34] discussed the relationship of housing to health and referred to the Hunzas, who are confined to their small dwellings by the stress of weather for two months each winter, and since they have little fuel, ventilation is reduced to a minimum to preserve heat. In spite of this their health is not impaired. He also referred to a survey made by Dr. Hilton Parry in Caernarvon town to discover the relationship between housing and tuberculosis. During 1934-36, 41 cases of tuberculosis were notified. Twenty-five of these were in good houses,

11 from fairly good and only 5 from poor dwellings. During the same period 26 died of the disease, 15 from good, 6 from fair and 5 from poor homes.

The remarkably low incidence of tuberculous infection occurring in children living in bad houses in Radnor was not therefore unique. This fact forcefully demonstrates that the undue prominence given to the question of bad housing in its relationship to a high incidence of tuberculosis has tended to confuse the real issue. It is the number of infecting foci in a slum area that is the most important factor. It is impossible to stress too strongly that with reference to tuberculosis housing is a secondary factor. Housing becomes important only when healthy persons are compelled by overcrowding and bad ventilation to inhale massive doses of germs. It should not be for a moment thought that the infinite importance of housing in maintaining general health, and even self-respect, is not fully appreciated. But re-housing the slum population without education, through which people can be taught to make the best use of their surroundings, will prove valueless.

The importance of nutrition is undoubtedly great. The maintenance of the optimum nutritional state is next in importance to the removal of the infecting reservoir in the prevention of the onset of tuberculous disease. A closely allied factor, almost inseparable from good nutrition, is fatigue. Fatigue, whether physical or mental, is equally detrimental to bodily well-being. It is strange that the part played by fatigue has not been given more prominence. Children in this county retire late to bed, and mothers were warned to send reactors to bed early to obtain adequate rest. Good feeding, however, will do much to allay the onset of fatigue. 14·9 per cent. of the reactors were subnormally nourished and 0·7 per cent. were badly nourished—a small percentage. However, in this, tuberculous infection as opposed to tuberculous disease was being considered. The important point to evaluate is, in which group will the largest number develop actual disease? Although the importance of good feeding in the prevention of the onset of tuberculous diseases is fully appreciated, it cannot be the only factor concerned, otherwise the relatively high incidence of tuberculous morbidity in the Royal Navy and Merchant Service would not occur, as the men in these services are very well fed and often have excellent physique. The men live under such conditions that they may, unaware to themselves, come in close contact with an infectious case of tuberculosis, and therefore be exposed to massive doses of tubercle bacilli. Adequate feeding and an optimum state of nutrition, for all their importance, cannot therefore be the complete solution to a sound resistance to tuberculosis.

Conclusions

1. A tuberculin survey using double strength Monrad jelly has been made of the elementary school population in the county of Radnor.

2. A preliminary investigation showed that the tuberculin patch test using double strength tuberculin jelly was 100 per cent. reliable compared with the Mantoux test.

3. The incidence of tuberculous infection was low—6·5 per cent.

4. Seventy-six per cent. of reactors were found to have been in direct contact with a case of pulmonary tuberculosis.

5. Investigation of the sources of contact infection among the children

examined showed that tuberculosis is a highly infectious disease under certain circumstances. Spread of tuberculous infection of the human type did not occur within the schools.

6. The incidence of tuberculous infection in Radnor bore no relationship to poor housing, bad sanitation, nutritional state, high rainfall, low mean temperature, low number of sunshine hours, exposure to rain-bearing winds, geological formation or susceptible anthropological types.

I wish to express my appreciation to Dr. N. T. K. Jordan, the Area Chest Physician, for his guidance, to Professor Tytler for preparing and supplying the tuberculin jelly, and to Dr. Clifford Hoyle for his invaluable help in redrafting the original paper.

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APPENDIX

Table IX.

Number in Register	*Age*	*Male or Female*	*Nutrition A—Good B—Normal C—Subnormal D—Bad*	*Contact with case of Tuberculosis*	*Degree of Reaction*	*Condition of Home, Good Fair or Bad*
1	10	F	B	+	++	Fair
2	8	M	B	+	++	Fair
3	9	F	C	+	+++	Fair
4	13	M	C	+	+++	Fair
5	7	F	A	—	+	Good
6	8	M	B	+	+++	Good
7	13	F	C	+	+++	Fair
8	9	F	A	+	+++	Good
9	12	M	C	+	++	Fair
10	11	F	A	+	++	Good
11	8	F	B	—	+	Fair
12	10	M	B	+	++	Fair
13	10	F	A	+	++	Fair
14	10	M	A	+	+++	Fair
15	6	M	B	+	+++	Good
16	6	M	A	+	+++	Bad
17	8	F	C	+	+++	Bad
18	11	M	C	—	+	Fair
19	9	M	A	+	+++	Good
20	10	M	B	+	+++	Fair
21	11	M	B	+	++	Fair
22	10	M	B	+	++	Bad
23	13	M	B	+	+	Fair
24	12	M	A	+	+++	Fair
25	12	F	A	+	++	Good
26	12	F	A	+	+++	Good
27	13	F	A	+	+++	Good
28	12	M	B	+	+++	Fair
29	11	M	C	—	++	Fair
30	12	M	C	—	+	Good
31	14	F	A	See Epidemiological Notes	+++	Good
32	12	F	C	+	++	Good
33	14	M	B	+	++	Good
34	14	F	B	+	+++	Fair
35	14	F	B	+	+++	Fair
36	14	F	A	+	++	Good
37	13	F	A	—	++	Good
38	13	F	B	+	+++	Fair
39	12	F	B	+	+	Good
40	13	F	A	—	++	Good

TABLE IX. (*continued*)

Number in Register	*Age*	*Male or Female*	*Nutrition A—Good B—Normal C—Subnormal D—Bad*	*Contact with case of Tuberculosis*	*Degree of Reaction*	*Condition of Home, Good Fair or Bad*
41	12	M	A	+	++	Fair
42	14	M	A	+	++	Good
43	10	F	A	See Ep. Notes	+++	Good
44	7	M	A	See Ep. Notes	+++	Good
45	13	M	A	See Ep. Notes	+++	Good
46	13	M	A	+	+	Fair
47	11	M	C	—	+	Bad
48	12	M	C	+	++	Fair
49	11	M	A	+	+	Good
50	10	M	A	—	++	Good
51	9	M	C	+	++	Bad
52	13	M	C	+	+++	Fair
53	9	M	C	—	++	Good
54	12	M	B	+	+	Fair
55	10	M	B	+	+	Fair
56	7	M	C	+	+	Bad
57	8	M	B	+	+++	Bad
58	6	M	B	+	+++	Bad
59	10	F	B	+	+++	Bad
60	5	M	B	—	++	Good
61	5	M	B	—	+	Good
62	7	M	B	+	+++	Fair
63	10	F	B	+	+++	Fair
64	9	F	A	+	+++	Bad
65	12	F	B	+	+++	Fair
66	9	F	B	+	+++	Good
67	9	F	B	+	+++	Bad
68	5	F	A	+	+++	Good
69	14	F	A	—	++	Good
70	8	M	A	—	+++	Good
71	10	F	B	+	++	Good
72	11	F	B	+	+++	Fair
73	7	M	B	+	++	Fair
74	5	F	B	+	++	Fair
75	8	F	C	+	++	Fair
76	5	M	B	+	++	Fair
77	10	M	A	+	+++	Fair
78	8	F	A	+	+	Fair
79	7	M	B	+	+++	Fair
80	9	M	B	+	+	Fair
81	9	M	C	+	+++	Fair
82	10	M	B	—	++++	Fair
83	10	M	A	+	++	Fair
84	13	F	B	—	++	Good
85	9	F	A	+	++	Fair
86	11	M	C	+	++	Fair
87	13	F	A	—	+++	Fair
88	13	F	B	—	++	Good
89	14	M	A	+	++	Good
90	12	F	B	+	+++	Fair
91	14	F	A	—	++	Good
92	14	M	B	—	+	Bad
93	13	M	B	+	+++	Bad
94	14	M	B	+	+	Fair
95	14	F	A	—	+	Good

TABLE IX. (*continued*)

Number in Register	*Age*	*Male or Female*	*Nutrition A—Good B—Normal C—Subnormal D—Bad*	*Contact with case of Tuberculosis*	*Degree of Reaction*	*Condition of Home, Good Fair or Bad*
96	13	M	B	+	+++	Fair
97	10	F	B	—	+++	Good
98	12	M	A	+	+++	Bad
99	9	M	C	+	++	Good
100	10	M	B	—	++	Good
101	11	F	B	+	+++	Fair
102	7	F	B	+	+++	Fair
103	7	F	B	+	+++	Bad
104	11	F	B	+	+++	Bad
105	9	M	B	+	+++	Bad
106	8	M	B	+	+	Bad
107	—	M	C	+	+	Bad
108	7	F	B	+	+++	Bad
109	5	F	B	—	+++	Fair
110	5	F	A	+	+++	Fair
111	13	M	B	+	+++	Fair
112	9	F	B	+	++	Bad
113	8	M	B	+	++	Fair
114	13	M	A	+	+++	Fair
115	11	M	B	—	++	Fair
116	7	F	A	—	++	Bad
117	7	M	B	—	+	Bad
118	9	F	B	+	++	Bad
119	8	F	A	+	+++	Fair
120	5	M	B	+	++	Bad
121	9	M	B	+	+++	Fair
122	6	F	B	+	+++	Fair
123	11	F	B	+	++	Fair
124	13	M	B	+	+++	Fair
125	11	M	A	+	+++	Fair
126	9	F	A	—	+++	Fair
127	11	F	D	—	+++	Fair
128	11	F	B	—	+	Bad
129	9	M	B	+	+++	Good
130	11	M	B	+	+++	Fair
131	9	F	B	+	+++	Fair
132	9	M	B	—	++	Fair
133	6	M	B	—	+++	Good
134	8	F	C	+	+++	Bad
135	10	M	B	+	+++	Bad
136	11	M	B	+	++	Fair
137	8	F	A	+	+++	Fair
138	7	F	A	+	+++	Fair
139	13	F	B	+	+	Fair
140	6	M	B	—	+++	Good
141	6	M	B	+	+++	Fair

NOTICES

THE First International Congress on Diseases of the Chest will be held at the Carlo Forlanini Institute, Rome, Italy, September 17-20, 1950, under the auspices of the Council on International Affairs of the American College of Chest Physicians and the Carlo Forlanini Institute, with the patronage of the High Commissioner of Hygiene and Health, Italy, in collaboration with the National Institute of Health and the Italian Federation Against Tuberculosis.

Physicians who are interested in attending the Congress should communicate at once with Dr. Chevalier L. Jackson, Chairman of the Council on International Affairs, American College of Chest Physicians, 500, North Dearborn Street, Chicago 10, Illinois, U.S.A., or with Professor A. Omodei Zorini, Carlo Forlanini Institute, Rome, Italy.

REFRESHER COURSES

Refresher courses are being arranged at Davos, Switzerland, and in London during the early part of 1950, and bookings for these can now be accepted.

The DAVOS Course *for doctors only* is being organised in conjunction with the Davos Medical Society, and will include clinical demonstrations. Subject to a sufficient number of applications being received, the Course will be held from March 25 to April 2, 1950. Expenses are estimated as follows: Fare approximately £20 (Second Class return); accommodation approximately 20 fr. per day; Lecture Fee, 20 fr.; Registration Fee, one guinea (payable in advance to the Secretary, Tuberculosis Educational Institute).

The LONDON Courses on TUBERCULOSIS IN CHILDREN AND THE USE OF B.C.G. will be of interest to doctors (especially those attached to the School Medical Service), school nurses, health visitors, administrators and social workers. They are to be held in the Medical School at St. Thomas's Hospital, S.E.1., on April 18, 19 and 20, 1950. Visits to a London Hospital and Chest Clinic will be arranged on April 21. The fee for doctors is four guineas, and that for school nurses and others one guinea.

Approval of the London Courses has been granted by the Minister of Education, who will take into account for purposes of grant reasonable expenditure by local education authorities in respect of attendance of their school medical officers and school nurses at the courses.

Three-day Clinical Courses are being continued at Cheshire Joint Sanatorium, Market Drayton, Salop, and at King George V Sanatorium, Godalming, Surrey. Dates arranged for the first six months of 1950 are as follows:—

Cheshire Joint Sanatorium: February 8, 9, 10; March 8, 9, 10; April 12, 13, 14; May 10, 11, 12.

King George V Sanatorium, Godalming: January 24, 25, 26; February 21, 22, 23; May 10, 11, 12.

Applications for further information and enrolment should be addressed to the Secretary, Tuberculosis Educational Institute, Tavistock House North, Tavistock Square, London, W.C.1.